WHERE IS THE BEAT?: COMPARISON OF FINNISH AND SOUTH-AFRICAN LISTENERS

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ABSTRACT

Listeners' ability to perceive pulse is assumed to relate both to the conventions of the musical system in ones culture and to the factors independent of the culture. A number of previous studies have investigated pulse perception but the interplay between culturally dependent and independent factors has been little studied. The aim of the study was to investigate the degree to which familiarity with a musical culture affects pulse perception. More specifically, the aim was to study whether tapping phase and accuracy depend on the listeners' cultural background. Excerpts of 16 African and 16 European folk songs were presented in two separate blocks to African (N=19) and European (N=20) listeners. The participants were instructed to tap to the pulse using a MIDI controller connected to a computer. Overall, the groups displayed similar tapping behaviour. There were, however, some differences between phase and accuracy of tapping, especially with certain African melodies. No significant differences between the two groups were found in the degree to which note onset histograms could predict the tapping phase. However, the extent to which the degree of consensus of tapping to the African melodies depended on the degree of conformance of their metric structure to Western metric hierarchy varied across participant groups: this dependence was significantly stronger for the European group, suggesting that the African group utilised style-specific knowledge in deducing the beat in the African melodies.

1. INTRODUCTION

A number of previous studies have investigated pulse perception using experimental methodology, such as tapping along with music. Moreover, pulse perception has been investigated with models based on a multitude of formalisms, including rule-based systems, statistical approaches, optimization approaches, control theory, connectionist models, information theory, linear signal processing, Bayesian estimation, multi-agent models, and oscillators.

Much of the modelling approaches are based on temporal factors of the stimulus, such as distributions of onsets and note durations, and aim to account for bottom-up processes involved in pulse perception. While a great deal of pulse perception can be explained by data-driven bottom-up processes, top-down processing, such as the influence of style- or culture-specific knowledge may also have an effect. These processes have, however, received less attention.

In the field of empirical cross-cultural studies on rhythm, Igaga and Versey studied synchronisation and repetition of rhythms with Ugandan and English children [1]. They found a marked superiority of Ugandan children over English in both tasks. While Temperley [2] has provided theoretical accounts on meter in both African and European music, there are no experimental investigations on the role of culture-specific knowledge on pulse and meter perception.

The present study investigates the degree to which familiarity with a musical culture affects pulse perception. More specifically, it aims to investigate whether tapping phase and accuracy depend on the listeners' cultural background and whether there are differences in the precision, to which these features can be predicted by surface features of music.

2. EXPERIMENT

2.1. Participants

Nineteen African (South-African) and twenty European (Finnish) students participated to the experiment. The mean age for African participants was 16.6 (SD 4.1) years and for European listeners, 17.2 (SD 1.6) years. All African participants had received 1-4 years of training in a Western musical instrument. The European participants were chosen from a special music emphasis class and had an equivalent degree of musical training.

2.2. Stimuli

Two sets of melodies were used: 16 African and 16 European folk songs were presented in two separate blocks. The European folk songs were chosen from the Essen collection [3] and the African folk songs from two collections [4, 5]. The melodies were all in duple meter and only the eight first bars of them were used. More background on these melodies is given in another study, where subsets of both melody groups are used in a different task [6].

All melodies were transposed to C mode and encoded as MIDI files with constant note-on velocity values. Minor tempo changes between the trials were introduced in order remove the interference from the previous trial and to keep the task more interesting for the participants. In African melodies, three tempo ranges were used (100, 106 and 112 BPM) and in European melodies, these were 114, 120, 126 BPM. The tempo changes were randomized across the blocks. Between the trials, a distractor was played to eliminate the pulse sensation from the previous trial. This distractor consisted of accelerating, constant-pitched vibraphone tones and was surrounded by 1500 ms pauses on both sides.

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2.3. Equipment

The stimuli were played from sequencer software running on a computer connected to Yamaha JV1010 synthesizer module that was amplified through Pioneer XR-A200 amplifier/speaker combination. The tap times were recorded as MIDI data into the sequencer program using an external MIDI drum machine. This setup offered the necessary low latency (less than 10 ms). In the European melodies, the timbre was set to English horn and in the African melodies, to Kalimba. A cowbell sound was used for the audible feedback for the tapping.

2.4. Procedure

The participants were told that they would take part in an experiment about rhythm and tapping to the beat of music. Their task was to quickly tap to the pulse or to the beat of the music using a special key in the drum pad. After getting familiar with the task, they rehearsed with two practice trials. The actual experiment had two blocks, each containing 16 experimental trials. The order of presentation was randomized using a Latin square design, counter-balancing between the participant groups the presentation of the European and African melodies as the first blocks.

3. RESULTS

Participants who failed to tap a steady pulse or synchronise with the majority of the stimuli were discarded from the analysis. This left 14 participants in the African and 15 in the European group.

3.1. Comparison of tap times

There were no significant differences with respect to inter-tap intervals (ITIs) for each group of participants and melodies. In all cases, the proportion of ITIs close to one quarter note was approximately 85%, while that of ITIs close to two quarter notes was approximately 15%.

To investigate the differences in tapping phase between the two participant groups, the tapping times, measured in units of one quarter note from the onset of the first note of each stimulus, were combined for each stimulus and each participant group. From each set of tap times, a tapping histogram was formed by rounding each tap time modulo two quarter notes to the nearest sixteenth note and calculating the distribution of the thus obtained values. This resulted in an eight-component histogram for each stimulus and each participant group. Each histogram was normalised to have a sum of components equalling unity. The reason for using two quarter notes as the period was that 99.7 % of all inter-tap intervals were shorter than 2.25 quarter notes.

Overall, the tap time histograms for the European melodies were similar across the participant groups, while there were larger differences between the participant groups in the African melodies. The mean city-block distance between the tap time histograms of African and European participants was 0.44 for the African melodies and 0.19 for the European melodies. This difference is significant (t=2.89, p<0.01). Furthermore, the melodies with the eight largest differences across the participant groups were all African. This is obvious, since the African participants had been exposed to European music and thus may not differ significantly from the European group with respect to the mechanisms they employed in finding the pulse in European melodies. Consequently, we deal only with the African stimuli where the largest differences were observed.

3.2. Onset times and tap times

For each stimulus, an onset time histogram was calculated in a manner similar to the tap time histograms, with the addition that each note was weighted by its duration. The city-block distance between the onset histograms and respective tap time histograms, averaged across stimuli, was 0.68 for the African participants and 0.72 for the European participants. Although this distance was smaller for the African group and thus the tapping behaviour of that group could be slightly better predicted by the onset time distribution, the difference was not significant (t=-0.41, n.s.).

3.3. Clarity of pulse and metric regularity

Next, we studied how the clarity of perceived pulse depended on the rhythmical structure of each stimulus. The clarity of perceived pulse was taken as the degree of consensus to which the participants in a group tap to a stimulus. To quantify the degree of consensus, we first estimated the tapping density by a Gaussian kernel estimator. This estimator was calculated by setting a Gaussian curve at each tap time for a given stimulus and participant group and summing those curves. Next, we calculated the entropy of each of the thus obtained tap density functions (for details, see [7]). The degree of consensus was defined as the negative of the entropy. Stimuli for which a participant group tapped in mutually identical phase and with a high accuracy had a tapping density with sharp and narrow peaks, yielding in low entropy and thus a high consensus value. The entropies for the African and the European participants, averaged across the African stimuli, were almost identical, 0.84 and 0.85, respectively. Therefore, according to this measure no overall difference between the degrees of tapping consensus of the participant groups was found.

To study the effect of metric regularity on tapping consensus we used a metric regularity measure that was based on the metrical grid by Lerdahl and Jackendoff [8]. The grid was represented by the vector $\mathbf{v}$ = (4, 1, 2, 1, 3, 1, 2, 1). Onset histograms calculated from Western music in 4/4 time typically have a form similar to vector $\mathbf{v}$ [9]. To obtain a measure of metric regularity of a given stimulus, all cyclically rotated versions of $\mathbf{v}$ were correlated with the onset histogram of the respective stimulus. The maximal value of all these correlations was taken as the measure of metric regularity. The obtained metric regularity values correlated more strongly with the tapping consensus values of the European group (r(14) = 0.85, p<0.0001) than with those of the African group (r(14) = 0.45, n.s.). This result suggests that for the European participants the clarity of perceived pulse was enhanced by the presence of a metrical structure typical of Western music, while for the African participants this feature had no effect.

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3.4. Analysis of differences

To obtain a more detailed view of the differences between the tapping behaviour of the two participant groups, the stimuli that showed the largest differences in terms of tap time histograms or tapping consensus were subjected to a more detailed analysis. Two main types of differences are reported below.

1. Melodies that contained successive dotted eighth notes usually had a higher tapping consensus within the African group that within the European group. The tap density functions suggest that this difference could be attributed to the difficulty of the European participants to synchronise with this kind of melodies. This phenomenon may be due to the predominance of such rhythmic motives in African music, one example of which is the clave rhythm common in various styles of West African and Latin American music [10]. Consequently, with those melodies the African participants may have employed style-specific knowledge in deducing the beat. An example of such a melody is presented in Figure 1.

2. In melodies where the European group had a higher tapping consensus than the African group, the difference often could be attributed to the fact that a subgroup of the African participants tapped in a phase shifted by one eighth note from that the rest of the African group and the whole European group. This is in accordance with the syncopation shift phenomenon observed by Blacking [11] and Temperley [2]. Figure 2 displays an example of such a melody. In addition, anticipation by one sixteenth note with respect to the European group was found in some melodies. These phase-shift phenomena may be attributed to some style-specific aspects, but their origin is not clear.

4. DISCUSSION

The present study investigated pulse perception of two participant groups, one African and the other European, using melodic material consisting of both African and European folk melodies. The task given to the participants was that of tapping the pulse to the melody they were presented with. The use of real melodies as stimuli together with an easy production task resulted in an ecologically relatively valid experimental setting. To the knowledge of the authors, similar comparative studies on pulse perception have not been carried out before. Besides studies on developmental psychology, such comparative studies may provide the only means for teasing out differences between data-driven and top-down processes in music perception.

Overall, no significant differences between the tapping behaviour of the two groups were found for the European melodies. A part of the African melodies, however, showed differences with respect to either the distribution of tap times or the tapping consensus. This result is understandable, since the African participants had been previously exposed to European music, while the European participants were relatively ignorant about African music.

No significant differences between the two groups were found in the degree to which note onset histograms could predict the tapping phase. However, the extent to which the degree of consensus of tapping to the African melodies depended on the degree of conformance of their metric structure to Western metric hierarchy varied across participant groups: this dependence was significantly stronger for the European group. A more detailed analysis of individual melodies and tap times associated with them suggested that the European participants had more difficulty than the African participants in synchronizing with melodies containing rhythmic motives similar to the clave rhythm. Furthermore, in some melodies a part of the African group deviated from other participants by a phase shift of either one eighth note or one sixteenth note. These results suggest that the African group may have utilised style-specific knowledge in deducing the beat in the African melodies.

The onset histograms provide a relatively simple model for predicting the tapping phase. In the present study, no differences between the participant groups were found with respect to the model's power of predicting the tapping phase. In subsequent experiments, more advanced beat-induction models, such as oscillators, will be utilised.

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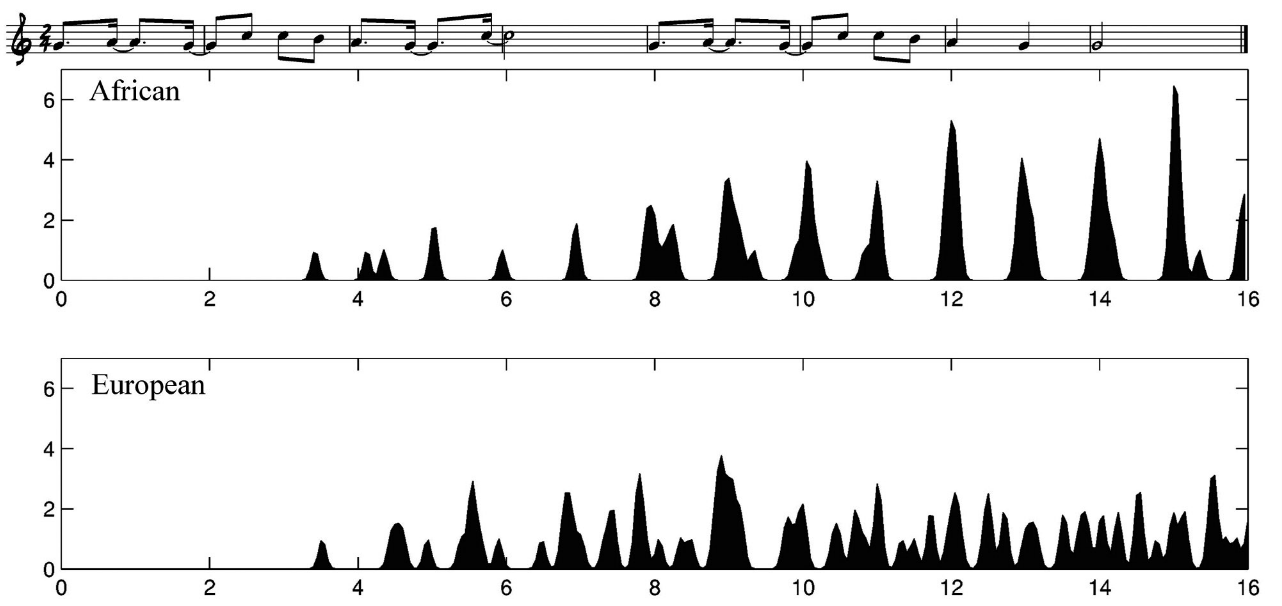

Figure 1: First eight measures of South African melody *Pela (Rock Rabbit)* [4] with tapping density functions shown separately for African and European listeners.

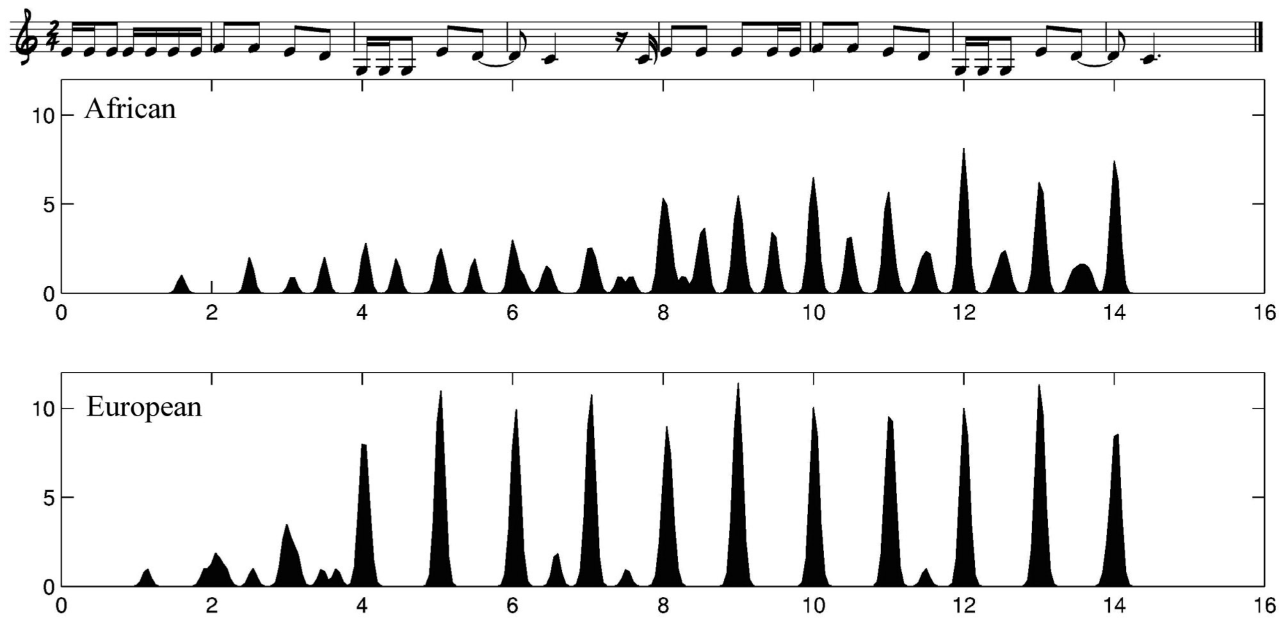

Figure 2: First eight measures of South African melody *Serantabola (An Umbrella)* [4] with tapping density functions shown separately for African and European listeners.

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